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Effect of Cooking Temperature and Time on the Tenderness of Precooked Freeze-dried Turkey White Meat

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SUMMARY

The effects of specific cooking temperatures for various time intervals on shear press values of turkey light meat were determined before and after freeze-drying. Cylinders of meat were used to obtain short temperature equilibration times. The cooking temperatures investigated were 140, 150, 160, 170, 180, 190 and 200°F. To relate the results to a common cooking method, turkey meat stuffed into casings 2½-in. in diameter was cooked in steam at 6 lbs pressure to internal temperatures of 160, 170, 180, 190 and 200°F. Half of the roll at each internal temperature was chilled in ice water immediately after reaching temperature. The other half was held in a water bath for 4 hr at the terminal internal temperature, then chilled in ice water.

The initial effect of heat on the tenderness of meat evaluated before freeze-drying was a toughening which reached a maximum at about 160°F. Holding at any given temperature up to 160°F resulted in very little change in the toughness initially obtained at that temperature. When the meat was evaluated after freeze-drying, the pattern was the same except that maximum toughness occurred at about 170°F. However, when the meat was cooked in casings and cooled quickly, the maximum toughness occurred at 190°F for the freeze-dried product and at 170°F for the product not freeze-dried. When the meat was held at the run temperature for 4 hr, the maximum toughness for both products occurred at 160°F. The freeze-dried product was significantly tougher than the product not freeze-dried. The cooking process must be specifically designed for freeze-dried turkey to obtain the most satisfactory product.

INTRODUCTION

Procurements of cooked freeze-dried turkey for field testing by the Armed Forces resulted in ratings by the using troops as much tougher than desired. As summarized by Wells (1966), there are many factors that affect the tenderness of poultry meat. Most of these factors would be difficult or impossible to control in Armed Forces procurement. However, control of the cooking process is feasible, and preliminary studies indicated that more acceptable freeze-dried turkey meat can be produced with proper cooking controls.

The observation that freeze-drying toughens poultry meat has been made by several investigators including Bele *et al.* (1966), Seltzer (1961) and Sosebee *et al.* (1964). Miller *et al.* (1965) noted that turkey meat, to be freeze-dried, may require quite different cooking, but did not investigate the various cooking factors.

In an investigation that included a study of the effects of end-point temperature on the tenderness of the light meat of turkey roasts, Goodwin *et al.* (1962) reported a decline in shear values (more tender) with increased temperature except for an increase at 71°C (160°F) and a sharp decline at 77°C. Goodwin (1963) reported the same effect. Wilkinson *et al.* (1967) reported a decline in shear values from 60 (140°F) to 66°C (151°F), a constant value to 82°C (180°F) and a slight (but statistically insignificant) rise between 82° and 88° (190°F). Hoke *et al.* (1967), in investigating the effect of internal and oven temperatures on the quality of light turkey meat, found that all significant changes in eating quality except for mealiness were due to the internal temperature rather than to oven temperature and that there was a statistically-significant increase in tenderness as the end-point temperature was increased from 161° to 212°F. However, in none of the four studies noted above was the meat freeze-dried.

Almost all reported studies on the cooking of poultry are concerned with whole or half birds or with turkey rolls. Usually, the product was placed in the cooking medium and held there until a given internal temperature was reached. This means that different points in the meat were subjected to widely varying cooking cycles depending upon the distance of a particular point from the surface. This investigation was designed to determine the effects of specific temperatures for varying periods of time. Thus, the cross section of the meat was made as small as possible to permit rapid temperature equilibration through the product.

EXPERIMENTAL METHODS

Grade A tom turkeys averaging 20–25 lbs were received in the fresh chilled state with no control of quality other than grade and condition. Immediately upon receipt, the turkeys were boned with only the breast meat being used for this study.

In Experiment I, the breast meat was ground through a 1-in. plate, carefully packaged in freezer paper, frozen to −30°F. in a blast freezer, and held at that temperature until used.

Product for cooking was allowed to thaw overnight at room temperature. It was tightly stuffed into stainless steel tubes, ⅞-in. internal diameter and 8-in. long. The tubes were suspended in a 200°F water bath until the product reached the temperature at which it was to be run and immediately transferred to a water bath at the run temperature. Tubes were removed at selected intervals and immediately cooled in 32°F water. Zero time was considered as the point when the product was transferred from the 200°F bath. Time required to bring the product up to run temperature varied from 3 to 8 min, depending upon the temperatures. Time required to cool the product down to less than 100°F was 3 min or less. Cooking temperatures used were 140, 150, 160, 170, 180, 190 and 200°F. Time intervals at these temperatures were 0, 1, 2, 3, 4, 5 and 6 hr. After chilling, the cooked meat was frozen in a −30°F blast freezer and cut on a band saw into 3/16-in. thick disks. Half of the disks were conditioned to 50°F to be tested in the shear press and the other half was freeze-dried.

Freeze-drying was accomplished in a pilot plant freeze-dryer with a plate temperature of 120°F and a pressure of 200–400 microns. Vacuum was broken with nitrogen. Upon completion of the drying, the disks were packed in cans with 28–29 in. of vacuum. Prior to the shear test, the disks were rehydrated in 80°F water for 10 min and then conditioned to 50°F.

The shear press results were obtained with an Allo-Kramer Shear Press, model 211E. Five of the meat disks were placed in a single layer in the Kramer cell for each test, and 30 replicates were run for each test. A downstroke of 30 sec and a 5000-lb ring were used with the press. Results were recorded as pounds force measured at the peak of the shear value.

To relate the results of Experiment I to realistic cooking situations, Experiment II was conducted using 2½-in. diameter rolls of light turkey meat formed by stuffing the boned turkey meat into flexible casings. The meat was not ground for this experiment. Two rolls were made from each turkey, and the identity of the individual turkeys maintained throughout the study. The two rolls from each turkey were brought up to a given internal temperature in a 6-lb steam chamber. Upon reaching temperature, one roll was immediately placed in ice water and chilled to below 100°F. The other roll was placed in a hot water bath at the temperature under study and held for 4 hr. At the end of this time, the roll was placed in ice water. The cooking temperatures used were 160, 170, 180, 190 and 200°F. The time required to bring the rolls to 160°F was about 30 min, and the time to cool them below 100°F was about 25 min. Four replications were performed.

The product from Experiment II was evaluated on the Allo-Kramer Shear Press under the same conditions as in Experiment I except that the meat used in the press was a circular slice 2½-in. in diameter and ¼-in. thick.

RESULTS AND DISCUSSION

Statistical analysis of the raw data in Experiment I showed significant time and temperature effects on the tenderness of the turkey both before and after freeze-drying. Cubic equa-

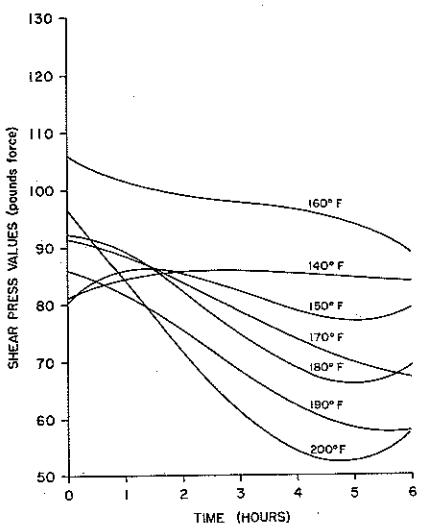

Fig. 1. The effect of cooking temperature and time on the shear press value for fresh-frozen light turkey meat.

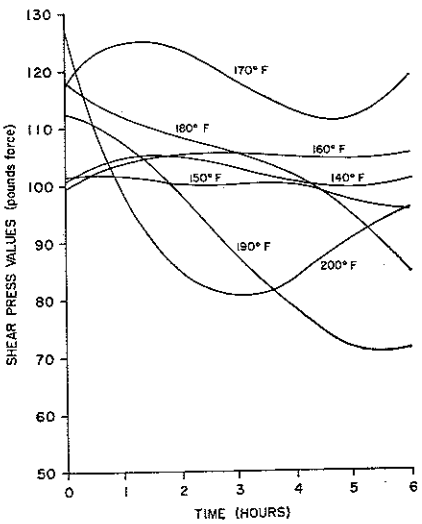

Fig. 2. The effect of cooking temperature and time on the shear press value of cooked freeze-dried turkey light meat.

Table 1. Shear press means for turkey light meat in Experiment II.[1]

Cooking temperature (°F)	Product cooled immediately		Product cooked 4 hr	
	Freeze-dried	Fresh-frozen	Freeze-dried	Fresh-frozen
160	61.4	52.4	71.9	56.0
170	61.5	61.6	70.5	55.3
180	59.5	55.7	55.8	44.1
190	67.5	56.7	68.7	46.3
200	63.4	52.1	61.6	43.8

[1] Results are the average of 4 replications using an Allo-Kramer Shear Press with the higher number indicating less tender product.

Table 2. Analysis of variance results of Experiment II.

Factor	Significance
Cooking temperature	*
Holding at cooking temperature	n.s.
Freeze-drying	**
Temp. × Holding	*
Temp. × Freeze-drying	n.s.
Holding × Freeze-drying	**

*—$P < 0.05$
**—$P < 0.01$
n.s.—not significant

tions of the shear press results were found by the method of least squares and are plotted in Figs. 1 and 2. Inspection of these plots confirms two results of previous investigators: (1) Freeze-dried turkey is considerably tougher than corresponding product before freeze-drying. (2) The tenderizing effect of increasing temperature is reversed somewhere in the vicinity of 170°F and then is resumed as the temperature is again increased. In this study, however, the toughening of the product before freeze-drying occurred at 160°F. When the product was freeze-dried the toughening occurred at 170°F. This indicates that optimum cooking for turkey light meat is not the same for products to be freeze-dried as for those not freeze-dried.

The time-temperature effects on turkey light meat were very similar to those found for beef (Tuomy *et al.*, 1963) and pork (Tuomy *et al.*, 1964). Increased holding time resulted in very little, if any, tenderization at temperatures from 140 to 160°F in the non-freeze-dried product and 140 to 170°F in the freeze-dried product. In both cases, tenderization increased more rapidly as the temperature was increased after the 160 and 170°F points were passed.

The average shear press results for Experiment II are shown in Table 1 and the analysis of variance results in Table 2. As in Experiment I, the freeze-dried product had significantly higher shear press values than the corresponding product not freeze-dried. When the meat was brought up to the run temperature and quickly cooled, the highest shear press values were found at 190°F for the freeze-dried and 170°F for the product not freeze-dried. This does not conform to the results found in Experiment I, except that there was a difference in the temperature at which the highest shear press value occurred. However, when the meat was held for 4 hr at the run temperature, the highest shear values occurred at 160°F for both freeze-dried and product not freeze-dried. This is much closer to the results of Experiment I.

It should be noted that all 4 columns in Table 1 show increased shear press values at 190°F, statistically significant in the case of the freeze-dried product but not in the case of the product not freeze-dried. This is similar to the results of Wilkinson *et al.* (1967) where an increase in shear press values was found between 82° and 88°C. In this case, turkey roasts were used and the product was not freeze-dried.

The results of this study indicate that the cooking process for freeze-dried turkey light meat should be carefully designed and controlled to obtain a more tender product. It is believed that this, in combination with other methods for improving tenderness, such as the use of enzymes, can result in an acceptable freeze-dried product.

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